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Vertical Hydroponic Farming with Technology

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***Abstract* —** The rising world population is posing threats to global food security. The problem is more serious in urban areas where there is scarcity of farming land and water. Further, global warming is making it more and more difficult to plant crops in an uncontrolled environment. In traditional soil based farming method, farmers require good quality of soil with natural minerals. Soil based farming consumes more resources such as water, fertilizers and space. It also requires higher working cost for tilling and removal of weeds.

Hydroponic farming is a soilless urban market gardening technique that aims at providing fresh farm products, at low costs mainly in urban areas. It has the potential of alleviating food security challenges. However, this practice requires constant monitoring of the farm environment.

Falling prices of advanced microcontroller boards and sensors is making it possible to control and monitor a farm without or with less human intervention.

And wireless sensing makes this even more convenient and less messier.

Keywords*—*PVC, CCTV, IoT, pH

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I. INTRODUCTION

Hydroponic farming is a method of growing plants without soil, using mineral nutrient solutions, in water. It is a soilless urban market gardening technique that aims at providing fresh farm products, at low costs mainly in urban areas. The earliest published work on growing terrestrial plants without soil was the 1627 book Sylva Sylvarum or 'A Natural History' by Francis Bacon. In 2013, Thanet Earth the UK's largest greenhouse complex, based in Kent used controlled environment agriculture to produce around 225 million tomatoes, 16m peppers and 13m cucumbers, which equated respectively to 12, 11 and 8 per cent of Britain's entire annual production of these crops. Thus hydroponic farming has the potential of solving food security problem. The major advantage of hydroponic farming is that is uses 80% less water than traditional soil based farming, does not require tilling and crops can be taken round the year, without depending on rain. Another very important plus point is that we are not limited by farming space since we can not only grow horizontally but also vertically.

However, since there is no soil which acts as a buffer, this practice requires constant monitoring of the farm environment. A small mistake can ruin the entire crop.

The main goal of this paper is to present a description and implementation of an economically viable method of monitoring and controlling hydroponic farm. And growing the crops vertically.

Falling prices of advanced microcontroller boards and sensors is making it possible to control and monitor a farm without or with less human intervention.

II. Ease of Use

A. Growing PlantsThe frame model is constructed using the PVC pipes that are available everywhere. They are sturdy, light in weight, easy to assemble and economically priced. The user just have to insert pregrown small sized plants that are initially grown in small pots using cocopeat.

B. Switching On the System

The user has to mix nutrients in water in a can, pour it in a water container and switch on the system. The microcontroller circuit takes care of everything without user intervention.

C. Monitoring the growth

User can monitor the growth of the plants using a CCTV camera and using a smart phone. The various parameters such as temperature, humidity and light can be monitored in real time on software like Thingspeak.

III. BLOCK DIAGRAM

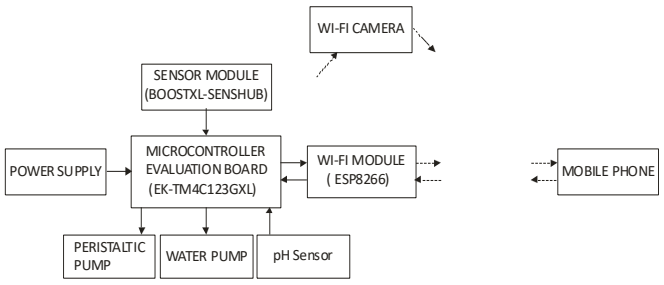

Fig. 1. Block Diagram of Vertical Hydroponic Farming With Technology

The Sensor Module Boostxl-Senshub is connected to the microcontroller evaluation board EK-TM4C123GXL.The evaluation board is powered by a USB adapter.

Since microcontroller board does not incorporate wi-fi module, a separate wi-fi module ESP-8266 is interfaced via port lines. ESP-8266 enables wireless communication with a mobile. The various parameters temperature, humidity and pH values of the water are sensed and transmitted to the mobile phone via wi-fi module ESP8266.

Also, since the Senshub sensor board does not incorporate pH sensor, a separate pH sensor is interfaced with the microcontroller board. pH sensor senses the purity of water which also indicates the nutrient contents. The nutrients are adjusted accordingly.

A water pump is interfaced with the microcontroller board. Water pump takes the water from the bottom tank to the top, from where it is showered on to the plants through sprayer inside the pipes.

A peristaltic/dosing pump is interfaced with the microcontroller board to administer the nutrients.

A wi-fi camera monitors the growth of the plants and transmits the images to a mobile phone.

IV.FRAME ASSEMBLY

Fig. 2. Frame For Hydroponic Farming

The frame is constructed from PVC plumbing pipes, which are easily available everywhere. They are sturdy, light in weight and economically priced. Further, since the pipes do not allow light to pass inside, fungal and algae growth is prevented.

4” pipes, T-joints and Knee joints are all that are required. Only certain joints are sealed with glue to prevent leakage. Certain joints – because we should also be able to disassemble the frame for portability and for maintenance purpose.

V. HARDWARE

A. Tiva C Series TM4C123 Launchpad

Texas Instruments Tiva C Series TM4C123G Launchpad kit is used for this project for the following reasons:

The Texas Instruments Tiva C Series microcontrollers (MCUs) are low-power, versatile and smart devices. The Tiva C Series consists of several devices that feature different sets of peripherals and are targeted for various applications. This project gives us exposure to Tiva C series which we can use for some other advanced applications in future.

The Tiva C series microcontrollers feature a powerful 32-bit ARM core, 80-MHz operation, and 100 DMIPS1 performance. These microcontrollers use Thumb-22 mixed 16-/32-bit instruction set that delivers high performance in a compact memory size usually associated with 8 and 16-bit devices.

The microcontrollers consist of a battery-backed hibernation module that provides logic to switch power off to the main processor and its peripherals while the processor is idle. It also wakes up the processor on external or time-based events. The features of this module include low-battery detection, signaling and interrupt generation, with optional wake-up on low battery. This makes microcontrollers of the Tiva C series suitable for low power battery applications.

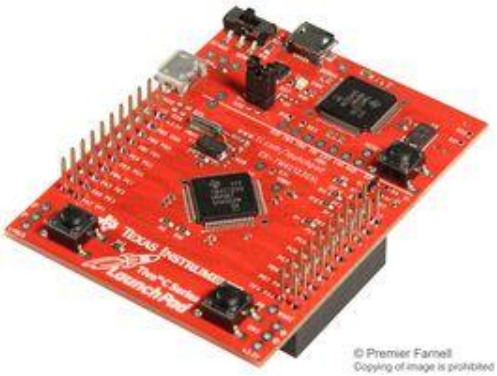

Fig. 3. Tiva C Series TM4C123G Launchpad Board

B. BOOSTXL-SENSHUB

TI has developed a Sensor Hub booster pack board that incorporates most of the sensors required for this project. Using this ready made board increases reliability and saves a lot of time. BOOSTXL-SENHUB has many other sensors. They are:

InvenSense MPU-9150: 9-axis MEMS motion tracking
3-axis gyro
3-axis accelerometer
3-axis compassBosch Sensortec
BMP180 pressure sensor

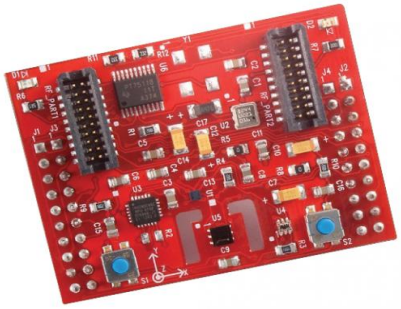

Fig. 4. BOOSTXL-SENHUB

The SENSHUB Booster Pack is expensive and many of its sensors are not used in this project, therefore, using discrete sensors DHT-11 and LDR is much more economical.

C. *DHT-11 Humidity & Temperature Sensor*

DHT-11 is a commonly used humidity and temperature sensor module that is easily available. It has only 3 pins viz. GND, DATA and VCC. The module works on 5 V. The data is transmitted serially over Data pin. Using DHT-11 saves cost.

Fig. 5. DHT-11 Sensor

The light can be sensed using a simple LDR. Since the LDRs are laminated on the top, they are also water-proof. LDRs have only 2 pins.

D. 16X2 LCD

A 16x2 LCD can be used to display the various parameters. This LCD is inexpensive and sufficient for my purpose. The backlight can be switched on to monitor the parameters in dark conditions.

Fig. 6. 16x2 LCD

E. pH Sensor Module

A pH sensor module is used to determine the concentration of nutrients.

Fig. 7. pH Sensor Module

F. ESP-8266 -01 WiFi Module

Since the evaluation board used here does not provide wifi, we have to used ESP8266-01 module.

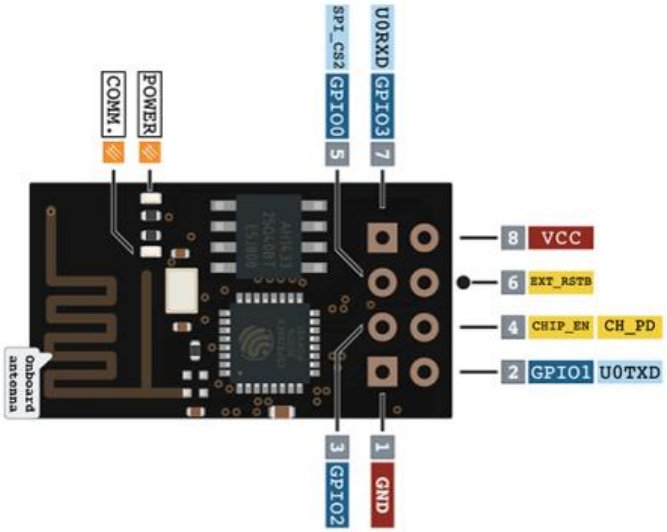

Fig. 8. ESP-8266 -01 Module

A high pressure pump is used to pump water in pipes so that it can be sprayed on to roots of the plants from inside the frame assembly.

VI. SOFTWARE

Keil uVision software is proposed to program the Tiva C series LaunchPad TM4C123G board. The program will be written in Embedded C.

TI's TivaWare development kit is required. This contains many useful files, including example µVision projects, which provide a good starting point for programming this evaluation board, as well as many drivers and libraries for the TM4C123G's peripherals. For the TM4C123G evaluation board, we will want to download SW-EK-TM4C123GXL-2.1.0.12573.exe. Run this executable and install it into a location of your choice. For this practice, we will assume the default directory C:\ti\TivaWare_C_Series. From TI's site, we will also want to download the drivers for the In-Circuit Debug Interface (ICDI) that allows us to upload and debug code on the TM4C123GXL.

Finally, we will download a serial terminal program so that we can easily see the output of the TM4C123G, which can help greatly when debugging. TeraTerm is a simple serial communication analysis software. It can be downloaded from SourceForge.

VII. MONITORING PARAMETERS

This project is basically an IoT project which involves monitoring various parameters required for the plant in real time, on a smartphone via internet. There are applications that let us use their servers to do this. And one of the most popular such application is ThingSpeak.

ThingSpeak™ is an IoT analytics platform service that allows us to aggregate, visualize and analyze live data streams in the cloud. ThingSpeak provides instant visualizations of data posted by your devices to ThingSpeak. ThingSpeak is often used for prototyping IoT systems that require analytics.

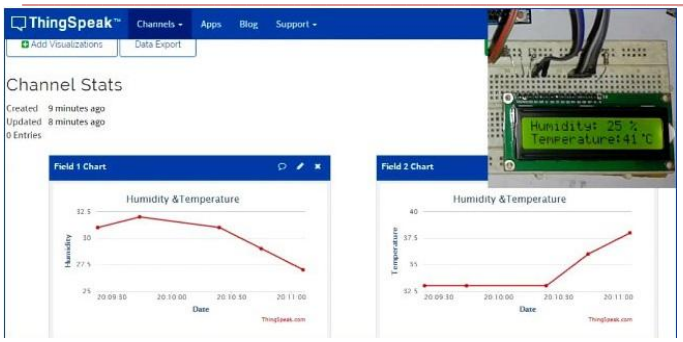

Fig. 9. ThingSpeak Real Time Graphs

VIII. CONCLUSION

Small plants can be grown without soil, only on water, if we provide required nutrients through water. And the growth of the plants can be monitored and controlled using sensors and microcontroller board.

Authors and Affiliations

The author has assembled the frame assembly, tested the hardware, software and successfully grown some crops using the method shown here.

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